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Bilingualism and the development of executive control

Inurritegui, Sandra **22 februari 2007**

Promotor: **Prof. Dr. G. d'Ydewalle**

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Bilingualism and the Development of Executive Control

Sandra Inurritegui

Supervisor: Géry d'Ydewalle

Laboratory of Experimental Psychology

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Bilingualism and the Development of Executive Control

The effect of bilingualism on cognitive development in children has been a matter of interest for many scholars as well as a source of discussion, partly because results from different studies lead to different and even conflicting conclusions. Research in the area has focused on examining whether there is an effect of learning two (or more) languages on cognitive development of children and the direction of this effect (if it is beneficial or detrimental), as well as on determining the scope of the effect by describing which cognitive functions might be involved and the mechanism responsible for the so called bilingual effect.

Current studies are focused on analyzing the effects that bilingualism has on specific cognitive processes rather than domains of skill development such as language ability and intelligence. They tend to conclude that bilingualism accelerates the development of a general cognitive function concerned with attention and inhibition (Bialystok, 2001, 2005)

The present research seeks to explore the association between bilingualism and attentional control. The aim is to explore the advantages derived from learning and using two (or more) languages simultaneously as well as to determine the cognitive processes and mechanisms involved.

To provide an adequate definition of bilingualism is a challenging enterprise. Generally speaking, earlier definitions tended to restrict bilingualism to equal mastery or native-like control of two languages, while more recent definitions have allowed much greater variation in competence and understand bilingualism as the alternate use of two or more languages by the same individual (Baetens Beardsmore, 1982; Edwards, 2004)

Rather than attempting to provide a definition, most scientists in the field prefer to work within a typology of bilingualism, providing a framework for a clear delimitation of the particular area of investigation within a larger field (for a review, see Baetens Beardsmore,

1982). A criterion that is commonly used is language proficiency. Taking proficiency into account, one distinguishes between *balanced* bilinguals, whose mastery of both languages is roughly equivalent, and *unbalanced* or non-fluent bilinguals. A similar distinction is proposed by Cummins (1987) who describe three types of bilingualism (limited, partial and proficient bilingualism), depending on the level of proficiency achieved by children in both languages. Other widely used criteria to differentiate types of bilingualism are when and how are both languages acquired. When the acquisition of more than one language is in pre-adolescence, it is referred to as *early* bilingualism; it is *late* bilingualism when one language is acquired before the age of more or less 11 years and new language(s) are learned at some age beyond this period. *Simultaneous* bilingualism refers to the exposure to more than one language from the onset of speech or from a very young age (generally 3 or 4 years-old) whereas *successive* bilingualism means that a new language (L2) is added to the existing first language (L1).

For the purpose of the present research, we are interested in examining balanced bilinguals whose proficiency level is age appropriate in both languages. Regarding the age of acquisition, we want to assess children who acquired both languages early in life.

1. Bilingualism and Cognition: Overview

The earliest studies that examined the relationship between cognitive functioning and bilingualism were conducted since the 1920's showing that bilingual children did more poorly and had lower scores on standard measures of verbal and nonverbal intelligence than their monolingual peers (Bialystok, 2001; Cook, 1997; Palij & Homel, 1987). However, since the Peal and Lambert's study of bilingual children in Montreal schools in 1962, research conclusions in this area turned into the opposite direction. Peal and Lambert (1962) criticized previous studies arguing that there were some confounded variables that were not adequately controlled, such as socio-demographic factors, cognitive equivalence of the samples and degree of bilingualism. Taking these factors into account, bilingual children performed significantly better than the monolingual group on both verbal and nonverbal measures; furthermore, the performance advantages by the bilingual children might be the result of greater mental flexibility (Peal & Lambert, 1962).

Since this turning point, research has been focused on determining in which aspects of the cognitive domain a bilingual advantage (such as general intelligence, conceptual development, divergent thinking and creativity, problem solving, linguistic and metalinguistic processing) is obtained. In general, most of the researchers in the area agreed that "the additive effects of using a second language seem to be an increased metalinguistic awareness of phonology, syntax, and the arbitrary nature of meaning, and gains in cognitive flexibility" (Cook, 1997, p. 294).

Regarding metalinguistic awareness, it has been suggested that "access to two languages in early childhood should affect the development on metalinguistic skills promoting an awareness of linguistic operations and a more analytic orientation to linguistic input" (Cummins, 1987, p. 57). Some studies found evidence of a bilingual superiority in metalinguistic tasks regarding the understanding of the arbitrary nature of language (Ben-Zeev, 1977; Cummins, 1978; Ianco-Worrall, 1972) as well as judgment of grammatical acceptability (Bialystok, 1986, 1988; Galambos & Goldin-Meadow, 1990; Galambos & Hakuta, 1988). However, others studies failed to replicate these results (for a review, see Bialystok, 2001; Cook, 1997; Palij & Homel, 1987). In order to systematize the findings regarding the relation between bilingualism and metalinguistic awareness, some authors pointed out the importance of taking into account individual differences such as the level of bilingual proficiency, as well as task differences (Bialystok, 2001; Galambos & Hakuta, 1988).

1.1 Bilingualism and Proficiency: the Threshold Hypothesis

The threshold hypothesis proposed by Cummins (1987) suggests that the level of proficiency bilingual children achieve in the two languages may be an important factor in determining the cognitive effects of bilingualism. There are three levels of bilingualism (see Figure 1). In *limited bilingualism*, the child has low levels of proficiency in both languages. In *partial bilingualism*, the child has achieved age-appropriate levels in one of the languages. Finally, in *proficient bilingualism* the child has age-appropriate level of proficiency in both languages.

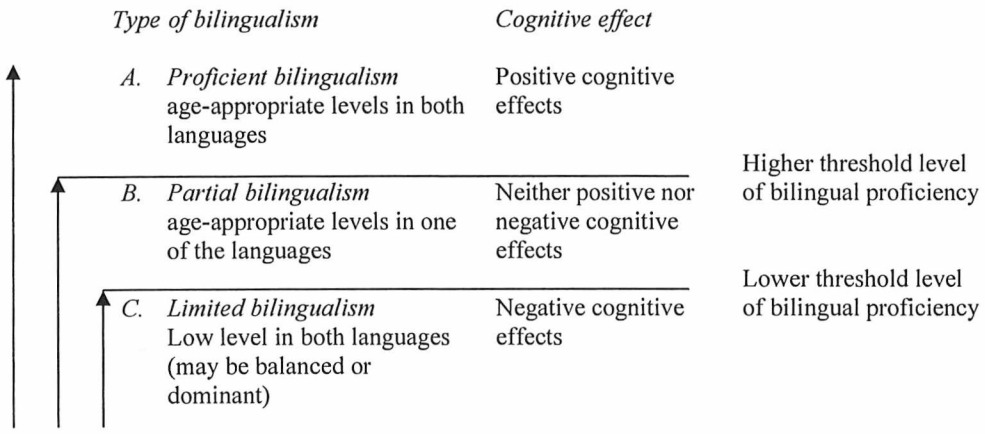

Figure 1. Cognitive effects of different types of bilingualism (Cummins, 1987)

Limited bilingualism leads to cognitive deficit, whereas proficient bilingualism results in cognitive benefits. Thus, there are two threshold levels of linguistic proficiency. The attainment of a lower threshold would be sufficient to avoid any negative cognitive effects, but the attainment of a second, higher level of bilingual proficiency may be necessary to lead to long-term cognitive benefits.

The distinction between two threshold levels of bilingual proficiency, with different cognitive consequences for each, is similar to the distinction between *subtractive* and *additive bilingualism* defined by Lambert (1974). In additive bilingualism, L2 brings to the speaker a set of cognitive and social abilities that do not negatively affect those that have been acquired in L1 but where the two linguistic and cultural entities involved in being bilingual combine in a complementary and enriching fashion. Such situation is brought when the society attributes positive values to both languages and considers the acquisition of L2 as an extra tool for thought and communication. The opposite situation arises with subtractive bilingualism where L2 is acquired at the expense of L1 and where, instead of producing complementarities between two linguistic and cultural systems, there is competition. The situation is prevalent in societies where the socio-cultural attributes of one of the languages are denigrated at the expense of those of the other, which has a more prestigious socio-economical status (Baetens Beardsmore, 1981).

Cummins suggested that the early findings of negative cognitive effects of bilingualism could be explained by the fact that the minority language children in these studies often failed to develop a sufficiently high level of proficiency in the school language to benefit fully from the educational experience. The rapid cognitive and academic progress of bilinguals reported in later studies is explained by the fact that these children had attained the upper threshold level of bilingual proficiency. Thus, "language acquisition context will affect the type of bilingualism attained, which in turn will strongly influence the long-term consequences of that bilingualism for overall cognitive and linguistic functions" (Cummins, 1987, p. 61).

Ricciardelli (1992) conducted a study to examine the predictions of the threshold hypothesis regarding the relationship between bilingualism and cognitive development. He tested five- and six-year old Italian-English bilinguals and English monolinguals, divided into subgroups according to their absolute proficiency in each language (high or low) as well as their relative proficiency (high-low/low-high) in both languages for the bilinguals, in a number of cognitive, creativity and metalinguistic awareness measures. Results were consistent with the threshold theory: There was a bilingual superiority only for children who attained a high degree of proficiency in both languages; bilinguals who were highly proficient in just one language did not differ from monolinguals; and bilinguals with low levels of proficiency in both languages performed more poorly than partially and proficient bilinguals.

1.2 Bilingualism and Cognitive Processing: Analysis and Control Framework

The analysis and control framework, proposed by Bialystok and Ryan (1985), describes two cognitive processes for considering the relation among different uses of language and their underlying requirements: Analysis (also referred to analyzed knowledge or representational processes) and control of attention. Analysis refers to the level of explicit structure and organization in which rules are represented. Control of attention is the executive function responsible for the selection and coordination of information given time constraints. It is described as the level of selective attention and inhibition recruited during cognitive processing that regulates access to and activation of mental representations (Bialystok, 2001; Bialystok & Ryan, 1985).

Within this framework, Bialystok (2001) reviewed previous research in an attempt to find a pattern in the bilingual effect. She claimed that bilingual children perform better than monolingual children in tasks that demand high levels of control, but there is no consistent advantage in tasks for which the solution relies primarily on high levels of analysis (Bialystok, 2001).

A task developed by Bialystok that seems to be useful to disentangle the development of both processes in metalinguistic awareness is the *grammaticality judgment task.* The task manipulates the demands on analysis and control by asking children to judge sentences for their syntactic acceptability, irrespective of meaningfulness. The sentences could be grammatical and meaningful (correct), grammatically correct but not meaningful (anomalous), meaningful but grammatically incorrect (ungrammatical) or both grammatically and semantically incorrect (wrong). The correct responses involved accepting correct and anomalous sentences and rejecting ungrammatical and wrong sentences. The critical items were the incongruent ones: Rejecting ungrammatical sentences represents a great challenge to analyzed knowledge to detect errors in grammar, and accepting anomalous sentences requires higher levels of control to ignore the meaning. Bilinguals were able to judge anomalous sentences more accurately than monolinguals, thus leading to the conclusion that there was a positive effect of bilingualism in the development of control of linguistic processing (Bialystok, 1986, 1988; Bialystok & Majumder, 1998; Cromdal, 1999).

Other studies analyzed the role of representational and control demands in different domains, such as the development of numerical concepts (Bialystok & Codd, 1997), non-verbal problem-solving abilities (Bialystok & Majumder, 1998; McLeay, 2003), and the development of a theory of mind (Bialystok & Senman, 2004; Kovács, 2005), comparing the performance of bilingual and monolingual children. Clearly, the bilingual superiority in the control of processing can be translated into other domains beyond language. In general, tasks with a bilingual advantage are characterized by the presence of misleading (usually perceptual) information and the need to choose between competing response alternatives; tasks based more heavily on analytic knowledge or detailed representations of knowledge, which are presented without a misleading context, are solved equally well by monolinguals and bilinguals (Bialystok, 2001).

1.3 Bilingual Control

Many models of bilingualism assume, explicitly or implicitly, the existence of separate language systems for the bilingual's two languages. Psycholinguistic studies on word recognition and language production with adults showed that the two languages of a bilingual remain constantly active while processing is carried out in one of them. Bilingual Interactive Activation Model (Dijkstra & van Heuven, 1998) assumes a nonselective access to words in the bilingual's two languages. Grosjean's analysis of language mode also suggests that both of the bilingual's languages are active to some degree (Grosjean, 1992). Current research in bilingual development is focused in understanding the mechanisms that allow bilinguals to process two linguistic systems as an attempt to find the higher order cognitive functions responsible for the advantages in controlling attention.

The Inhibitory Control (IC) model of Green (1998) describes the regulatory processes that permit a bilingual to perform in a given task in one language rather than another and proposes inhibition as the mechanism by which bilinguals control the activity of the two language systems. The proposal is derived from a model of action by Norman and Shallice (1986) in which there are distinct systems for controlling routine and non-routine behavior. The system responsible for routine behavior involves a process, termed contention scheduling: Schemas, triggered by perceptual or cognitive cues, compete to control behavior by altering the levels of activation. Where automatic control is insufficient, contention scheduling is modulated by a supervisory attentional system (SAS). The IC model has three components: a hierarchy of language task schemas, lexical representations and a selection mechanism based on inhibition. A regulatory system (SAS) controls levels of activation by regulating the language tasks schemas. The tasks schemas determine the output by controlling the activation levels of competing responses from the two languages and inhibiting lemmas that belong to the language incorrect for the situation. Thus, the central mechanism in this model is inhibition of competing lexical representations.

Evidence for the role of an inhibitory control mechanism on language selection in bilinguals comes from experiments on language switching conducted by Meuter and Allport (1999, Meuter, 2005). Their views on bilingual control involve the notion of global inhibition of either of the language subsystems. Similar to Green (1998), their study was embedded in a

more general theory of cognitive control. They focused on "paradoxical" asymmetries observed when participants have to switch between an easy, behaviorally dominant task and a more difficult, behaviorally weaker task (Rogers & Monsell, 1995). The cost that accompanies a switch between tasks is typically larger when the participant has to switch from a weaker to the more dominant task than with the switch in the reverse direction. This counterintuitive effect is explained in terms of differences in the required level of suppression of the non-target task, in combination with a phenomenon called "task set inertia": To enable a task performance, the non-target task must be actively suppressed and the target task must be activated. The stronger the non-target task, the more it has to be suppressed in order not to interfere with the target-task performance. Meuter and Allport (1999) replicated the paradoxical asymmetry with a group of unbalanced bilinguals who had to switch unpredictably between numeral naming in L1 and L2. As expected, switch trials were slower than non-switch trials, and the switch cost was larger from L1 to L2 than from L2 to L1. The results strongly suggest that bilingual language production requires the suppression of the non-target language and activation of the target language, and that the degree of suppression depends on language strength.

Bialystok also claims that the joint activity of the two systems requires a mechanism for keeping the languages separate and suggest, following Green's IC model, that the non-relevant language is suppressed by the same executive functions used generally to control attention and inhibition (Bialystok, 2001). The proposals of bilingual control assume that the language switching is a special case of task switching in general. Therefore, bilingual language control shares its basic underlying mechanisms with control of action. The processing advantage in bilinguals stems from the necessity to manage two activated languages; bilingual children need to selectively attend to the language in use and inhibit the other to avoid interference. The constant exercise of the inhibitory control provides bilinguals with an enhanced ability to ignore distracting and irrelevant stimuli, not only in language tasks but also in general cognitive processing.

In order to assess the hypothesized impact of bilingualism over executive control and attentional processes, Bialystok et al. carried out studies using performance-based assessment

tasks that allowed them to evaluate the common processing that underlies a range of cognitive abilities.

Martin and Bialystok (2003) tested six-year old monolingual and bilingual children using the Simon task. In this task, children are asked to press the red (left) or the blue (right) button when they see a red or a blue square, respectively. The stimuli are presented in either the left or the right side of the screen, in congruent (red square – left; blue square – right and incongruent (red square – right; blue square – left) conditions. Thus, in order to respond accurately, misleading location cues must be ignored in the incongruent conditions. As expected, bilinguals were faster (not more accurate) than monolinguals; but contrary to prediction, the speed advantage was obtained for both congruent and incongruent trials. They proposed that the advantage for bilinguals might lie, not in the enhanced ability to inhibit the misleading spatial cue but in the ability to manage attention to a complex set of rapidly changing task demands. This involves attentional control, which is a general executive process. Further support for the idea that the bilingual advantage relies on executive control processes comes from Bialystok and Feng (2005). They examined the performance of six- and eight-year old bilingual and monolingual children in the Flanker Task, where children are asked to press a key on the side that shows the direction of the middle arrow on four conditions, presented on blocked and mixed trials. In the congruent condition, the middle arrow is presented among other arrows pointing to the same direction as the target one. In the incongruent condition, the target arrow in surrounded by arrows in the opposite direction. In the neutral condition the middle arrow is presented among neutral stimuli that don't imply direction. In the no-go condition the stimuli around the arrow serves as a signal to inhibit the response. Bilingual children outperformed monolinguals in error rate on mixed block trials that, again, depend on inhibition of attention to misleading cues (Bialystok & Feng, 2005).

Bilingual advantage in inhibitory control for ignoring perceptual information was also shown in performance on the dimensional change card sort task. The task requires children to follow a simple rule to sort a set of cards and then to reverse that rule to sort the same cards in a different way. Bilingual children adapt to the new rule and solve this problem earlier than monolinguals (Bialystok, 1999; Bialystok & Martin, 2004). Bialystok and Shapero (2005) investigated if the bilingual advantage in executive processing extends to a new domain,

clearly distinct from linguistic skills, namely the ability to reinterpret ambiguous figures. They found that six-year old bilingual children were more successful than monolinguals in seeing the other meaning of the image. The results are explained by a reinterpretation of the ambiguous figure which "requires control over attention to select aspects of the figures, inhibition of the previous interpretation and reassigning of a new meaning to the same stimulus" (Bialystok & Shapero, 2005, p. 602).

In summary, current research regarding bilingualism and cognitive development provides support to the claim that bilingualism boosts executive functioning across domains. However, the concept of executive function is rather vague; there is no consensus about its definition, its nature, and its structure.

Executive function could be understood as an umbrella term that refers to "a complex cognitive construct that encompasses the set of processes that underlie flexible goal-directed behavior (e.g. planning, inhibitory control, attentional flexibility, working memory)" (Hughes, 2002). Hughes, Graham, and Grayson (2004) explain that executive function is thought to be necessary in situations that involve learning of new skills, planning and decision making, error correction or troubleshooting, initiation novel sequences of actions, danger or technical difficulty, conscious moment-to-moment control of behavior, the need to overcome strong habitual responses. The notion of executive functions is also linked with Baddeley's concept of central executive, which is assumed to be responsible for the attentional control and regulation of the working memory system (Baddeley, 1996, 2002, 2003; Baddeley & Logie, 1999).

The central executive is considered to play various executive functions and therefore is often referred to as "fractionated" (Baddeley, 1996, 2002; Shallice, 2002); that is, subdivided into different component processes. Baddeley (1996) analyzed the components of the central executive in an attempt to fractionate and understand a range of executive processes to be taken into account by an adequate model of executive control, such as coordinating performance on two separate tasks, selectively attend to one stimulus and inhibit the disrupting effect of others, switching attention between two or more stimulus sources or actions, and activating representations within long-term memory. In a revision of the model,

Baddeley (2003) proposed a new component, the episodic buffer, to provide an interface between the subsystems of working memory and long-term memory. The central executive is then regarded as the attentional controller responsible of focusing, dividing and switching attention.

In sum, the central executive in principle may not be a unitary concept and this issue is a main focus of current research within this framework. The strategy has been to begin by postulating the capacities that are needed by any attentional controller: "If we can define and analyze a range of several executive processes, then we would be in a position to begin to ask whether they are better regarded as individual and separable functions or whether a unitary account could be given" (Baddeley, 1996, p. 8). Miyake et al. (2000) carried out a study to specify the degree to which three often postulated executive functions - inhibition of prepotent responses, information updating and monitoring, and mental set shifting- are separable or share de same underlying ability or mechanism. Results suggested that, even though they are clearly distinguishable, the three latent variables share some underlying commonality, showing signs of both unity and diversity.

2. Present Study

2.1 Objective and Hypothesis

The purpose of the doctoral project is to test the predictions of a positive effect of bilingualism on control of attention. In order to examine the relation between bilingualism and executive control, we conducted a first study to compare performance of monolingual and bilingual children in both metalinguistic awareness and executive function tasks.

Metalinguistic development is measured, using the grammaticality judgment task of Bialystok (1986, 1988). The task consists in asking children to judge sentences for the grammatical acceptability without paying attentions to the meaning. Based on grammaticality and meaningfulness, there were four experimental conditions (sentence types): correct (grammatical and meaningful), ungrammatical (ungrammatical but meaningful), anomalous

(grammatical and meaningless) and wrong (ungrammatical and meaningless). Bilinguals were hypothesized to perform better than monolinguals in the anomalous sentences, given that the anomalous sentences require higher levels of control to ignore meaning.

The bilingual advantage is investigated in the three executive functions as described by Miyake et al. (2000): inhibition, switching and updating, using an adapted version of the tasks designed by Helsen and Schaeken (2005).

In the inhibition task, children were instructed to press as fast as they could the mouse button on the same side of a blinking face when they see a happy face (control condition), and not to press when they see a surprised face (inhibition condition). In the mental shift task, children had to press the mouse button on the same side of the blinking face when they saw happy faces and press the mouse button on the other side of the blinking face when they saw sad faces. The task included two baseline conditions (only "repeated" trials, one with happy and one with sad faces, counterbalancing the order of presentation between subjects) and two mental shift conditions ("repeat" and "switch" trials). The "shift cost" was calculated as the difference in reaction times between the baseline and the mental shift conditions. Finally, in the updating task, children were presented happy faces (with left or right blinking) that could be red, green or yellow. Participants were asked to press as fast as they could the mouse button on the same side of the blinking face. At the same time, they had to keep track of the number of faces that were presented in each color and answer a question about the number of faces of a certain color.

If the bilingual advantage in executive control stems from the need of bilinguals to manage two languages, bilingual children were predicted to outperform monolinguals; the processing advantage was predicted to be present in the three executive functions tested. As explained before, language use for bilingual speakers requires focusing attention in one language and inhibiting the other, which provides them with an increased ability to ignore distracting and irrelevant stimuli. Clearly then, bilingualism might exert an effect in the inhibition component of the executive function. Additionally, bilingual speakers also need to monitor their own performance and switch back and forth between languages depending on the communicative situation.

2.2 Preliminary Results

The study included 46 participants from second and fourth grade; 29 children were monolingual Dutch speakers (13 in second and 16 in fourth grade) and 17 were bilingual speakers of Dutch and another language (eight in second and nine in fourth grade). Language proficiency was assessed using the Dutch version of the Peabody Picture Vocabulary Test (Dunn, Dunn, & Schlichting, 2004). As expected, children in fourth grade obtained higher vocabulary scores than children in second grade, but there were no significant differences in performance between language groups (Table 1).

Results from this study provide support to the claim that bilingualism promotes an advantage of control in linguistic processing. Grammaticality Judgment data, both accuracy and reaction time measures (Table 2 and Table 3, respectively), were analyzed with language group (monolingual, bilingual) and grade (second and fourth grade) as between-subjects variables, and with two within-subject variables (meaningfulness and grammaticality). Anomalous sentences were more difficult for monolinguals than correct sentences (they made more mistakes) while there was no difference for the bilingual group. This indicated that ignoring the distracting meaning in order to judge grammaticality implied a greater challenge for monolingual than for bilingual children. In terms of reaction times, performance showed that children responded to anomalous sentences slower than to the other conditions, which supports the idea that these sentences were demanding more attentional resources. However, the differences were rather small.

Regarding the second hypothesis about a facilitating effect of bilingualism in the development of executive functions, the results were somehow confusing. Data of the three executive function tasks (Table 4) were examined with a two-way ANOVA (language group and grade). Bilingual children in fourth grade responded more accurately in the inhibition task and showed less switch cost in the mental shift task. Nevertheless, the interaction between language group and grade was not significant for the Inhibition task and only marginally significant for the Mental Shift task. On the other hand, in the updating task results were contrary to the hypothesis: Bilinguals in second grade performed more poorly than monolinguals.

Finally, in order to explore the role of attentional control on linguistic processing, the ANOVA of the grammaticality judgment task was repeated, including this time the scores of the executive functions tasks as continuous predictors. Results failed to show any effect of the continuous predictors on the performance in the grammatical judgment task.

2.3 Discussion

Although the first study provides evidence in favor of the claim that bilingualism exerts a positive effect in the development of control in linguistic processing, results are not clear in terms of a generalized advantage in attentional control. Thus, it is necessary to analyze why the relation between executive functions and bilingualism did not emerge from both a methodological as well as a theoretical point of view.

There are a number of methodological issues that could help us understand why results failed to show the expected bilingual advantage in executive control. First, the number of participants was limited and the sample was not balanced: There were more monolinguals than bilingual children tested. Moreover, the bilingual group was quite heterogeneous, not only with respect to the languages spoken by the children, but also regarding the conditions in which they became bilingual. Taking into account that we only assessed proficiency in one of the languages (Dutch), it might be the case that some of the children included in the bilingual group were not balanced or proficient bilinguals. As suggested by Cummins Threshold Hypothesis, level of proficiency in the two languages may be an important factor in determining the effects of bilingualism on cognitive development: Higher levels of proficiency in both languages may be necessary to lead to long-term benefits (Cummins, 1987). Therefore, selection of participants should be more rigorous to make sure that children included in the bilingual group are proficient in both languages and to avoid other possible confounding variables.

There are also some theoretical considerations regarding the tasks used to assess executive functions in the study.

In the inhibition task, children had to react to certain stimuli (happy faces) but not to others (surprised faces). However, it seems that these are not the kind of tasks in which the bilingual advantage emerges. Some authors proposed to distinguish between behavioral inhibition and cognitive inhibition (Harnshfeger, 1995; Nigg, 2000). Behavioral inhibition refers to the ability to suppress prepotent (motor) responses while cognitive inhibition deals with the active suppression of mental contents. Bilingual children excel in situations when there are competing representations one of which mush be ignored. Resolving the competition involves attention to one representation and ignoring the other, a task that is highly practiced by bilinguals, who need to manage the two languages by selectively attending to one and inhibiting the other. The inhibition task in the first study is a behavioral inhibition task; it does not require solving a conflict between competing representations, and therefore failed to grasp the kind of attentional control that is enhanced in bilinguals.

Switching refers to the ability to shift back and forth between multiple tasks, operations or mental sets. This process involves the disengagement of a no longer relevant task set and the subsequent active engagement of a relevant task set (Rogers & Monsell, 1995). When bilinguals are required to switch from one language to another, they need to inhibit the language in use and to activate the language that was previously suppressed. The Mental Shift task in the first study was a response switching task, but it did not require children to alternate representations, which is the executive function highly practiced by bilinguals.

3. Future Directions

It is clear then that the next step in this research is to design and conduct further experiments that clarify the bilingual advantage in tasks that require control of processing as well as to determine which executive functions are involved. Given that Bialystok et al. claim that the functions contributing to executive control include selective attention to relevant aspects of the problem, inhibition of attention to misleading information, and switching between competing alternatives (Bialystok, Craik, Klein, & Viswanathan, 2004), the relation between bilingual development and the development of these executive functions will be further explored.

Therefore, the purpose of the present research will be to compare performance of bilingual and monolingual children in these executive control processes, the first regarding selective attention and inhibition, and the second concerned with switching mental representations. An advantage of bilingual children in both executive functions is predicted.

Selective attention and inhibition are clearly distinguishable processes. Nevertheless, the so-called bilingual effect has been attributed to an enhanced ability to exert inhibitory control in ignoring distracting and irrelevant stimuli (Bialystok, 2001). Although inhibition has become a central topic in numerous research domains within psychology, there is no consensus in the literature regarding its definition. Moreover, the equally vague concept of resistance to interference or interference control is often used interchangeably with the term inhibition. Therefore, several theorists have proposed that inhibition processes are a family of functions rather a single unitary construct (Dempster, 1993; Friedman & Miyake, 2004; Harnishfeger, 1995; Nigg, 2000).

Harnishfeger (1995) classified inhibition processes according to whether inhibition takes place at a behavioral or at a cognitive level. Behavioral inhibition is the automatic or intentional delay of overt motor response; cognitive inhibition requires the active suppression of mental contents. He also made a distinction between inhibition and resistance to interference, where inhibition is an active suppression process that operates on the contents of working memory while resistance to interference is a gating mechanism that prevents irrelevant information or distracting stimuli from entering working memory. Following this framework, Nigg (2000) defined four types of effortful inhibition: interference control (preventing interference due to resource or stimulus competition), cognitive inhibition (suppression of irrelevant information to protect working memory or attention), behavioral inhibition (suppression of prepotent responses), and oculomotor inhibition (effortful suppression of reflexive saccade; this last type is sometimes included within behavioral inhibition). As Friedman and Miyake (2004) pointed out, these distinctions among different kinds of inhibition roughly correspond to different stages of information processing: An initial perceptual stage where relevant information must be selected and irrelevant information must be ignored (resistance to interference or interference control), inhibition at an intermediate level once information has entered working memory (cognitive inhibition), and an output

stage in which relevant responses must be selected and incorrect ones resisted (behavioral inhibition).

As pointed out before, a bilingual advantage in inhibitory control is expected in situations that require solving a conflict between competing representations by selectively attending to one and inhibiting the other; that is, in situations that resemble managing two activated languages. What remains unclear is whether the bilingual effect over control of processing emerges as an improved control of interference at an initial stage of processing (interference control), as an enhanced ability to suppress mental representations from working memory (cognitive inhibition), or as a more developed skill to select adequate responses and resist incorrect ones (behavioral inhibition). Within the present research this matter needs further to be clarified.

According to Bialystok et al., evidence for a positive effect of bilingualism over control of attention comes from an improved performance of bilinguals on the Stroop task (Bialystok, 2006), the Simon task (Bialystok, et al., 2004; Martin & Bialystok, 2003) and the Flanker task (Bialystok & Feng, 2005). However, results from these studies are difficult to interpret because it is not clearly stated which type of inhibition they involve. There is also the task impurity problem that generally emerges when trying to assess inhibition-related functions (Friedman & Miyake, 2004).

In the Stroop task, participants are asked to name the colors in which words are printed, ignoring the dominant tendency to read the words. Although the Stroop task has been sometimes classified as a resistance to interference task (Nigg, 2000), there is no consent over the specific process it measures; it has also been used to tap response inhibition (Friedman & Miyake, 2004; Miyake, et al., 2000), given that the response that must be avoided is dominant. Likewise, the Simon task assesses the extent to which the prepotent association to irrelevant spatial information affects participants' response to tasks-relevant nonspatial information. Therefore, this task grasps mainly behavioral inhibition. Behavioral inhibition is usually assessed using the stop-signal task and the go/no go paradigm (Friedman & Miyake, 2004; Nigg, 2000). In the stop-signal task, once participants have built up a prepotent response to certain stimuli, they are requested to withhold their responses on a small proportion of trials during which they hear an auditory signal (Friedman & Miyake, 2004). In

the go/no go paradigm subjects must withhold responding to an inappropriate stimulus while responding to other stimulus. Given that the majority of trials require an active response (go), participants must inhibit a (prepotent) tendency to respond on all trials on the minority of no-go trials. Interference control is commonly measured with tasks in which participants have to select targets presented with irrelevant distractors (Friedman & Miyake, 2004; Nigg, 2000), such as the Flanker paradigm, in which participants are asked to identify a target stimulus (e.g., a letter) that is presented either alone or with response-incompatible stimuli flanking it.

In the present research, a modified version of the flanker task designed by Bunge et al. (2002) will be used. This task combines the Eriksen flanker and the go/no-go paradigms and therefore is suitable to measure both behavioral inhibition and interference control. On each trial, subjects view an array of five stimuli on the screen, including a central arrow (target) and two stimuli on either side of it (flankers). They are asked to respond by pressing the left button when the central arrow points to the left and by pressing the right button when it points to the right.

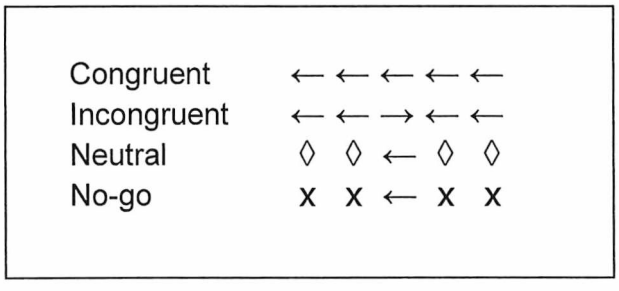

Figure 2. Experimental conditions on the modified version of the flanker task (Bunge et al, 2002)

The task includes four experimental conditions: congruent, incongruent, neutral, and no-go (Figure 2). On congruent trials, the flankers are arrows pointing in the same direction as the target. On incongruent trials, the flankers are arrows pointing in the opposite direction of the target. On neutral trials, the flankers are diamonds, stimuli not associated with any response. On no-go trials, the flankers are X's, which indicate that the subjects should withhold their responses. Interference control is measured as the difference in performance between neutral and incongruent trials; behavioural inhibition is the difference between neutral and no-go trials.

We are also interested in examining the effect of bilingualism in the ability to switch between mental representations. Switching has also been considered as an important aspect of executive control; it involves the disengagement of a no longer relevant task set and the subsequent active engagement of a relevant task set (Rogers & Monsell, 1995). In a typical switching experiment, subjects are pre-trained on two or more simple tasks afforded by a set of stimuli; each task requires attention to different elements or attributes of the stimuli. Then, stimuli are presented on a series of trials and the subject performs one of the tasks, which can change from one trial to the next or not. Performance can be analyzed when the tasks changes for evidence of extra processing demands (switch cost). Bialystok's studies supporting the claim that there is a bilingual advantage on task switching showed that bilinguals were better than monolinguals in the dimensional change card sort task (Bialystok, 1999; Bialystok & Martin, 2004) and in the embedded figures test (Bialystok & Shapero, 2005). The ability to hold in mind two sets of instructions and execute the correct task in response to a cue might be similar to the need to hold two language representations in mind and switch between them to respond in the appropriate language to the context demands.

The notion of executive functioning is receiving a great deal of attention nowadays. Nevertheless, it is still poorly understood given that there is no consensus about its definition and structure. By analyzing the bilingual advantages in executive control, this study could contribute to clarify the notion of executive functioning as well as to understand its processing components.

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Table 1
Mean scores (and standard deviations) on the Peabody Picture Vocabulary Test

Grade	Monolingual	Bilingual
Second Grade	106.7 (10.3)	107.3 (15.3)
Fourth Grade	119.8 (11.1)	118.9 (18.4)

Table 2
Mean accuracy scores (and standard deviations) on the Grammaticality Judgment Task by group and grade

	Monolingual		Bilingual	
Sentence type	2nd Grade	4th Grade	2nd Grade	4th Grade
Correct	0.94 (0.12)	0.96 (0.07)	0.94 (0.09)	0.97 (0.05)
Ungrammatical	0.82 (0.28)	0.90 (0.15)	0.89 (0.10)	0.83 (0.25)
Anomalous	0.67 (0.32)	0.83 (0.29)	0.83 (0.30)	0.87 (0.15)
Wrong	0.82 (0.17)	0.88 (0.14)	0.91 (0.09)	0.88 (0.12)

Table 3
Mean reaction times (and standard deviations) in milliseconds on the Grammaticality Judgment Task by group and grade

	Monolingual		Bilingual	
Sentence type	2nd Grade	4th Grade	2nd Grade	4th Grade
Correct	3304.9 (548.6)	3039.2 (434.9)	3207.4 (410.3)	3270.3 (529.3)
Ungrammatical	3356.5 (391.9)	3071.5 (321.5)	3420.9 (449.6)	3368.2 (578.3)
Anomalous	3561.1 (993.5)	3442.9 (802.2)	3711.7 (489.8)	3527.9 (692.7)
Wrong	3500.2 (659.1)	3207.7 (362.2)	3428.9 (602.2)	3257.3 (464.9)

Table 4
Mean scores (and standard deviations) for Executive Function tasks by group and grade

	Monolingual		Bilingual	
Task	2nd Grade	4th Grade	2nd Grade	4th Grade
Inhibition	.70 (.32)	.76 (.28)	.73 (.26)	.84 (.18)
Shift cost	772 (339)	814 (332)	910 (308)	597 (215)
Update	.78 (.14)	.78 (.17)	.57 (.18)	.74 (.21)